

IN THE CLAIMS:

1 1. (Currently Amended) In a file server having a storage operating system, a method for
2 managing storage of data in a plurality of storage devices, each storage device having a
3 plurality of blocks for storing data, comprising:

4 generating block layout information in a file system layer of the storage operating
5 system by determining which blocks within the plurality of blocks are allocated for
6 storing data and which are unallocated;

7 transferring the block layout information from the file system layer to a RAID
8 layer of the storage operating system; **and**

9 responsive to the block layout information, controlling ~~the~~ execution of I/O
10 operations at the RAID layer by identifying a plurality of contiguous blocks on a single
11 storage device within the plurality of blocks for use by each I/O operation so as to

12 substantially maximize chain lengths of read operations for calculation of parity;

13 determining whether a parity subtraction method or a recalculation method
14 requires a fewest number of read operations to calculate parity for the I/O operations;

15 selecting the parity subtraction method or the recalculation method for parity
16 calculation based on the which method that requires the fewest number of read
17 operations to compute parity for the I/O operations; and

18 responsive to the block layout information and the parity calculation method
19 selected, identifying the contiguous blocks within the plurality of blocks for use by the
20 I/O operations.

1 2. (Currently Amended) A method for managing storage of data in a plurality of storage
2 devices, each comprising a plurality of storage blocks, comprising:

3 generating block layout information;

4 determining whether a first methodology or a second methodology requires a
5 fewest number of read operations to calculate parity; and

6 in response to the block layout information and the determination, controlling
7 execution of I/O operations by identifying a plurality of contiguous storage blocks on a
8 single storage device for use by each I/O operation so as to substantially minimize athe

9 number of read operations needed for calculation of error correction parameters across a
10 | stripe disposed among the plurality of storage devices.

1 3. (Original) The method of claim 2 wherein the calculation of error correction
2 parameters comprises the calculation of parity.

1 4. (Currently Amended) The method of claim 3-2 wherein the calculation of parity
2 comprises selecting a parity calculation operation from a group consisting of a
3 | subtraction method as the first methodology and a parity re-calculation method as the
4 | second methodology.

1 5. (Currently Amended) The method of claim 2 wherein the identification of contiguous
2 storage blocks for use in the I/O operation substantially maximizes a chain length by
3 | substantially maximizing the-a number of blocks having a contiguous physical layout on
4 | the single storage device.

1 6. (Currently Amended) The method of claim 2, further comprising:
2 | identifying the contiguous storage blocks for use in the I/O operation so as to
3 | substantially maximize the chain length by substantially maximizing the-a number of
4 | blocks having sequential volume block numbers (VBNs) associated with the plurality of
5 | storage blocks.

1 7. (Currently Amended) The method of claim 2, further comprising:
2 | identifying the contiguous storage blocks for use in the I/O operation so as to
3 | substantially maximize the chain length by substantially maximizing locality of the
4 | contiguous blocks of the single storage device.

1 8. (Currently Amended) The method of claim 2 wherein the controlling execution step
2 comprises:

3 examining storage blocks to which data is to be written prior to write operations;
4 and
5 selecting ~~one of a plurality of parity calculation methodologies including either,~~
6 ~~a~~the first methodology comprising minimizing a number of blocks read, ~~and~~or
7 ~~a~~the second methodology comprising maximizing chain lengths of blocks read
8 for calculating parity calculation.

1 9. (Currently Amended) The method of claim 8, wherein ~~the~~ controlling execution step
2 further comprises:

3 implementing selection of the parity calculation methodology responsive to the
4 block layout information; and
5 wherein, if the selection constitutes ~~substantially~~ minimizing the number of
6 blocks read,

7 determining on a stripe-by-stripe basis whether to calculate parity based on a
8 subtraction method or a recalculation method,

9 performing any appropriate read operations to support the method selected, and
10 calculating parity responsive to the number of blocks read and the data to be
11 written; and

12 wherein, if the selection constitutes ~~substantially~~ maximizing chain lengths of
13 blocks read,

14 deciding which storage blocks to read to ~~substantially~~ maximize chain length
15 while ~~substantially~~ minimizing the number of ~~storage~~ blocks read to support either ~~a~~the
16 subtraction method or ~~a~~the recalculation method,

17 performing read operations on the number of blocks ~~to be~~ read, and

18 calculating parity responsive to the number of blocks read and the data to be
19 written.

1 10. (Currently Amended) The method of claim 2, wherein ~~the identification of identifying~~
2 the contiguous storage blocks is based at least in part on an available resource.

1 11. (Original) The method of claim 2 further comprising transmitting the block layout
2 information from a file system layer to a RAID layer.

1 12. (Currently Amended) The method of claim 2 wherein ~~the generating step~~ further
2 comprises:

3 making a first determination as to whether a storage block is unallocated;
4 making a second determination as to a current implementation of the plurality of
5 storage devices; and
6 generating the block layout information based at least in part on the first and the
7 second determinations.

1 13. (Currently Amended) The method of claim 2, wherein the I/O operation is one of a
2 plurality of I/O operations and at least one of the plurality of I/O operations is a read
3 operation.

1 14. (Currently Amended) The method of claim ~~2, 5~~, wherein the chain length is a chain
2 length of a read operation for calculation of parity.

1 15. (Currently Amended) The method of claim ~~2, 5~~, wherein the chain length is a chain
2 length for a write operation for the data.

1 16. (Currently Amended) A method for managing storage of data in a storage system,
2 comprising:

3 maintaining a plurality of storage devices each having a plurality of storage
4 blocks; and
5 writing data to predetermined storage blocks of the plurality of storage blocks
6 across a plurality of stripes and to predetermined contiguous storage blocks within each
7 storage device so as to substantially maximize chain lengths of the predetermined
8 contiguous storage blocks within each storage device and minimizing a number of read
9 operations for the calculation of error correction parameters across each stripe of the

10 plurality of stripes by determining whether a parity subtraction method or a recalculation
11 method requires a fewest number of read operations to calculate parity, and selecting thea
12 parity subtraction method or thea recalculation method for parity calculation based on the
13 which method that requires the fewest number of read operations to compute parity.

1 17. - 38. (Cancelled)

1 39. (Currently Amended) A storage system, comprising:
2 a plurality of storage devices each having a plurality of storage blocks; and
3 a storage manager in communication with the plurality of storage devices, the
4 storage manager configured to write writing data to predetermined storage blocks across
5 a plurality of stripes and to predetermined storage blocks within each storage device so as
6 to substantially maximize chain length of the plurality of storage blocks by selecting as
7 many as-contiguous storage blocks within a single storage device while substantially
8 minimizing a number of read operations required for calculation of error correction
9 parameters across each stripe of the plurality of stripes by determining whether a parity
10 subtraction method or a recalculation method requires a fewest number of read operations
11 to calculate parity and selecting at the parity subtraction method or at the recalculation
12 method for parity calculation based on the which method that requires the fewest number
13 of read operations to compute parity.

1 40. (Currently Amended) A system for managing the storage of data, the system
2 comprising:

3 a plurality of storage devices each having a plurality of storage blocks;
4 a storage device manager in communication with the plurality of storage blocks;
5 a block layout information generator in communication with the storage device
6 manager and the plurality of storage blocks; and
7 an error correction parameter calculator in communication with the plurality of
8 storage blocks and the storage device manager,

9 wherein the storage device manager, in response to the block layout information
10 from the block layout information generator, controls ~~the~~ execution of an I/O operation
11 by identifying a plurality of contiguous storage blocks on a single storage device for use
12 by the I/O operation so as to ~~substantially~~ maximize chain length within the single
13 storage device while ~~substantially~~ minimizing ~~the~~a number of read operations required
14 for calculation by the error correction parameter calculator of error correction parameters
15 across a stripe by determining whether a parity subtraction method or a recalculation
16 method requires a fewest number of read operations to calculate parity for the I/O
17 operations and selecting ~~a~~the parity subtraction method or ~~a~~the recalculation method for
18 parity calculation based on ~~the~~which method ~~that~~ requires the fewest number of read
19 operations ~~to compute parity~~.

1 41 - 44. (Cancelled)

1 45. (Previously Presented) A method for managing storage of data by a server,
2 comprising:
3 receiving a request to write the data to a plurality of storage devices;
4 generating block layout information to determine which blocks within a plurality
5 of blocks located in the plurality of storage devices are allocated ~~for storing~~ data and
6 which are unallocated;
7 identifying blocks within the plurality of blocks for use by a set of I/O operations
8 ~~to store the data~~;
9 determining ~~the~~a number of read operations needed to ~~compute~~calculate parity
10 for the data by ~~computing~~calculating parity using a subtraction method ~~of~~of computing
11 parity;
12 determining ~~the~~a number of read operations needed to ~~compute~~calculate parity
13 for the data by ~~computing~~calculating parity using a recalculation method ~~of~~of computing
14 parity;
15 choosing either the subtraction method of ~~computing~~calculating parity or the
16 recalculation method of ~~computing~~calculating parity by determining which ~~of these two~~

17 methods requires ~~the a~~ fewer number of read operations, and choosing the which method
18 that requires ~~requiring~~ the fewer number of read operations; and
19 writing the data to the identified blocks, and ~~computing calculating~~ parity for the
20 data using the ~~chosen~~which method of ~~computing~~ parity.

1 46. (Previously Presented) The method of claim 45, further comprising:
2 choosing to either ~~firstly~~ maximize chain lengths of read operations for
3 ~~calculation of calculating~~ parity or ~~secondly~~ choosing to place the data with a high degree
4 of locality in the plurality of storage devices, by choosing the which method ~~which that~~
5 requires the ~~fewest~~fewer number of read operations ~~in computing parity for the data~~.

1 47. (Currently Amended) A method for managing storage of data by a server,
2 comprising:
3 receiving a request to write data to a plurality of storage devices;
4 generating block layout information to determine which blocks within a plurality
5 of blocks located in the plurality of storage devices are allocated ~~for storing~~ data and
6 which are unallocated;
7 identifying blocks within the plurality of blocks for use by a set of I/O operations
8 to store the data; and
9 ~~selecting determining, in response to the block layout information, whether to~~
10 ~~substantially minimize the a number of read blocks or whether to substantially maximize~~
11 ~~chain lengths of read blocks based on which method requires a fewer number of read~~
12 ~~operations, and~~
13 implementing ~~the a~~ selection, during the writing of the data to the plurality of
14 storage devices, responsive to the block layout information, and responsive to whether
15 ~~substantially minimizing the number of read blocks or substantially maximizing chain~~
16 ~~lengths of read blocks requires the fewer number of read operations.~~

1 48. (Currently Amended) The method of claim 47, further comprising:

2 in response to selecting to ~~substantially~~ minimize the number of read blocks,
3 determining whether to calculate parity based on ~~the-a~~ subtraction method or ~~the-a~~
4 recalculation method ~~by determining based on~~ which method requires the fewer number
5 of read operations, ~~and selecting the method which requires the fewer number of read~~
6 ~~operations;~~ and

7 performing the write operation and calculating the parity using ~~the-which~~ parity
8 calculation method ~~requiring~~ ~~requires~~ the fewer number of read operations.

1 49. (Currently Amended) The method of claim-48 ~~47~~, further comprising:

2 in response to selecting to ~~substantially~~ maximize chain lengths of read blocks,
3 deciding which storage blocks to read to ~~substantially~~ maximize chain lengths while
4 minimizing the number of storage blocks read to support either the subtraction method or
5 the recalculation method ~~of parity calculation~~; and

6 performing the write operation and calculating the parity using ~~the-which~~ parity
7 calculation method ~~requiring~~ ~~requires~~ the fewer number of read operations.

1 50. (Currently Amended) A method for managing storage of data by a server,

2 comprising:

3 receiving a request to write data to a plurality of storage devices;

4 generating block layout information to determine which blocks within a plurality
5 of blocks located in the plurality of storage devices are allocated ~~for storing data~~ and
6 which are unallocated;

7 identifying blocks within the plurality of blocks for use by a set of I/O operations
8 to store the data;

9 testing to either maximize chain lengths of read operations for calculation of
10 parity, or to place the data with a high degree of locality in the plurality of storage
11 devices, the testing ~~having the steps comprising~~,

12 determining, for both maximizing chain length and placing the data with ~~a~~ ~~the~~
13 high degree of locality, ~~the-a~~ number of read operations needed to ~~compute~~ ~~calculate~~

14 parity for the data, by ~~computing calculating~~ parity using both ~~the-a~~ subtraction method
15 of ~~computing calculating~~ parity and ~~the-a~~ recalculation method of ~~computing calculating~~
16 parity;

17 ~~firstly first~~ choosing to either maximize chain lengths of read operations for
18 calculation of parity or to place the data with ~~a~~~~the~~ high degree of locality in the plurality
19 of storage devices, and after ~~this~~~~the~~ first choice, secondly choosing either the subtraction
20 method of ~~computing calculating~~ parity or the recalculation method of ~~computing~~
21 ~~calculating~~ parity by determining which of these methods requires ~~the-a~~ fewest number of
22 read operations,

23 choosing ~~the~~~~which~~ method ~~requiring~~~~requires~~ the fewest number of read
24 operations of ~~computing calculating~~ parity of the data; and

25 writing the data to ~~the~~ identified blocks, and ~~computing calculating~~ parity for the
26 data using the ~~chosen~~~~which~~ method of ~~computing~~ parity.

1 51. (Currently Amended) A computer readable media, comprising:

2 said computer readable media containing instructions for execution on a processor
3 for a method of managing storage of data in a plurality of storage devices, each storage
4 device having a plurality of blocks for storing data, the method ~~having comprising,~~
5 generating block layout information; and

6 in response to the block layout information, controlling ~~the~~ execution of an I/O
7 operation by identifying a plurality of contiguous storage blocks on a single storage
8 device for use by the I/O operation so as to ~~substantially~~ minimize ~~the-a~~ number of read
9 operations needed for calculation of error correction parameters across a stripe by

10 ~~determining whether a parity subtraction method or a recalculation method requires a~~
11 ~~fewest number of read operations to calculate parity for the I/O operations and~~ selecting
12 ~~the~~ parity subtraction method or ~~the~~ recalculation method for parity calculation based
13 on ~~the~~~~which~~ method ~~that~~ requires the fewest number of read operations ~~to compute~~
14 ~~parity.~~